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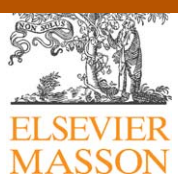

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ORIGINAL ARTICLE

# Is patella eversion during total knee arthroplasty crucial for gap adjustment and soft-tissue balancing?

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**KEYWORDS**
Patellar eversion;
Soft-tissue balance;
Joint gap inclination;
Total knee arthroplasty;
Mini-invasive technique

**Summary**
*Introduction:* Assessment of soft-tissue balance by the gap technique in Total Knee Arthroplasty (TKA) impacts femoral component rotation positioning. Proper femoral component rotation is a critical factor in TKA, both for adequate patellar tracking and in achieving a symmetrical flexion gap. Soft tissue balance assessment and gap measurements are performed at 90° flexion and with the patella everted in conventional TKA; during MIS-TKA, this step is performed with the patella in situ. We therefore investigated intraoperative joint gap parameters at 90° flexion with and without patellar eversion during conventional TKA, so as to better understand the influence of this intraoperative patellar position factor on final ligament balance.
*Hypothesis:* Conducting TKA without patellar eversion increases both gap size and gap inclination.
*Patients and methods:* Twenty-four osteoarthritic knees were included in the study. Joint gap size and inclination were measured intraoperatively on a knee in 90° flexion, with and without patellar eversion.
*Results:* The joint gap with patella in situ (17.0 ± 3.4 mm) was significantly greater than with patellar eversion (15.4 ± 3.0 mm), as was gap inclination at 90° flexion with the patella in situ (4.9 ± 3.1°) compared to with patellar eversion (4.0 ± 2.9°).
*Discussion:* The flexion gap inclination obtained without patellar eversion was steeper than with patellar eversion. This induced more externally rotated femoral positioning in absence of patellar eversion. These results ought to be taken into account by surgeons considering switching from conventional to MIS-TKA.
*Level of evidence:* Level III. Prospective study.


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## Introduction

In our facility, total knee arthroplasty (TKA) with posterior cruciate ligament resection was classically performed on a medial parapatellar approach using the so-called gap technique [1,2]; in June 2007, however, we started using minimally invasive surgery TKA (MIS-TKA) with a mini midvastus approach [3—5]. Soft-tissue balance measurement by the gap technique influences femoral component rotation in TKA, and proper rotational alignment of the femoral component is an important factor in patellar tracking and flexion gap symmetry [6—8]. Soft-tissue balancing and joint gap measurement are performed with patellar eversion and without setting the femoral component at 90° flexion in conventional TKA, and without patellar eversion in MIS-TKA. The measurements of tissue balance and joint gap in MIS-TKA may thus be different from those in conventional TKA [9,10]. This may impact postoperative outcome (femoral component rotation, joint gap, and postoperative range of motion [ROM]). Some reports show that patellar reduction lowers tension in the lateral relative to the medial gap of the knee [11].

We, therefore, investigated soft-tissue balancing and joint gap at 90° flexion in conventional TKA, according to patellar position (eversion or not, in the same knee).

Our hypothesis was that tension in the lateral gap is greater with patellar reduction, while tension in the knee extensor system is lower, so that the flexion gap may be greater with patellar reduction than with patellar eversion without the femoral component in situ, because the flexion gap is measured after making the distal femur cut.

## Patients and methods

A prospective study was made of 24 consecutive conventional TKAs in 23 patients between January and November 2007, using the gap technique. There were five men (six knees) and 18 women (18 knees) with a mean age of 77.0 years (range, 68—84 years). The preoperative diagnoses were medial osteoarthritis in 23 knees and rheumatoid arthritis in one knee.

**Figure 2** Measurement of intraoperative 90° flexion gap and intraoperative joint gap inclination (varus inclination counting as positive) with the thigh held in position and the leg raised.

A posterior stabilized (PS) prosthesis (Scorpio, Stryker, Mahwah, NJ) was used in all knees; both femoral and tibial components were cemented, and the patella was resurfaced in all cases. A medial parapatellar approach was systematically used. The proximal tibial cut was perpendicular to the tibial axis, and the distal femoral cut was made using intramedullary instrumentation with respect to the angle between the anatomical and mechanical axes of the femur. Ligament imbalance in the coronal plane was then assessed using a JDK offset balancer (Stryker, Mahwah, NJ) (Figs. 1 and 2), in extension. Medial structure soft-tissue was released to obtain proper ligament balance in knee

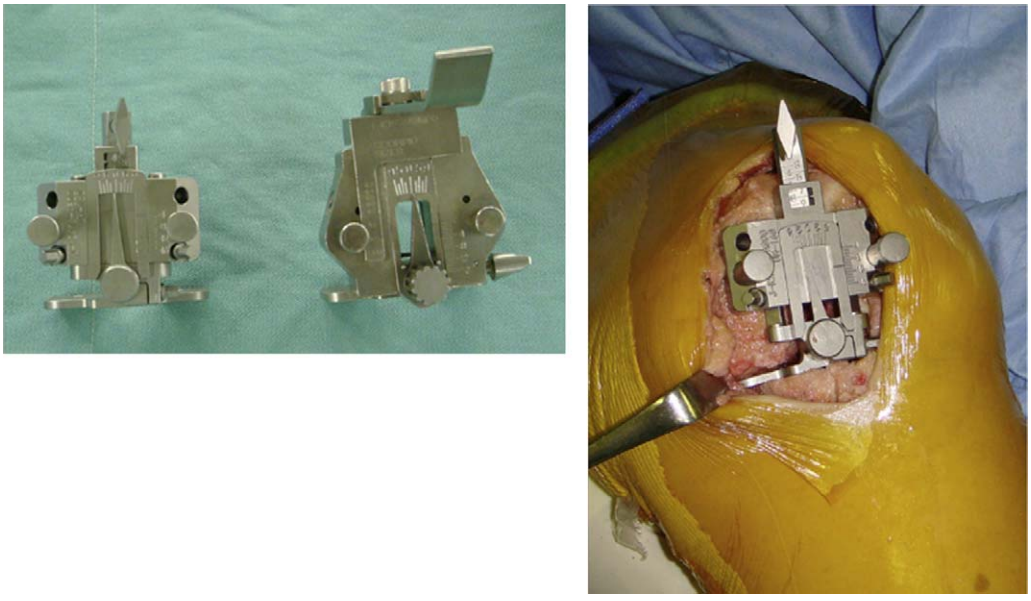

**Figure 1** JDK offset balancer (Stryker).

extension, and the posterior capsule was released from the posterior aspect of the femur if necessary. Proper soft tissue balance was defined as intraoperative joint-gap inclination of 0° to 3° in extension. Joint traction was set at 30 lb (approximately 13.6 kg), because the joint gap in full extension with 30 lb joint traction best approximates insert thickness (preliminary clinical study, not reported). Loading was repeated until the joint gap maintained a constant value, in order to reduce error due to creep elongation of surrounding soft tissue.

The intraoperative gap at 90° flexion (in the mid part of the knee) and its inclination with and without patellar eversion, with the thigh held in position and the leg raised, were then measured. The JDK offset balancer showed differences in tightness between the medial and lateral compartments, indicated by an angle, which defined the intraoperative inclination of the joint gap. If the medial compartment was tight, the angle was defined as positive. All of the procedures to measure joint gap and soft-tissue balance were performed by the senior author (Y.M.).

Results were analyzed using the Wilcoxon test, with the significance threshold set at $P<0.05$.

## Results

Mean intraoperative joint gap at 90° flexion was 15.4 ± 3.0 mm (range, 9.0 to 21.0 mm) with patellar eversion, and 17.0 ± 3.4 mm (11.0 to 24.0 mm) with patella in situ. Mean intraoperative joint-gap inclination at 90° flexion was 4.0 ± 2.9° (range, −1.0 to 8.0°) with patellar eversion and 4.9 ± 3.1° (range, −3.0 to 10.0°) with patella in situ. Joint gap and joint gap inclination were both significantly greater with patella in situ than with patellar eversion ($P=0.048$ and 0.036, respectively; see Table 1).

**Table 1** Comparison of intraoperative joint gap and intraoperative inclination of joint gap at 90° flexion between patellar eversion and patella in situ.

| | Patella eversion | Patella in situ | *P*-value |
|---|---|---|---|
| Intraoperative joint gap (mm) | 15.4 ± 3.0 | 17.0 ± 3.4 | 0.048 |
| Intraoperative joint-gap inclination (°) | 4.0 ± 2.9 | 4.9 ± 3.1 | 0.036 |

(mean ± SD) Wilcoxon signed-ranks test.

## Discussion

In a comparative study of flexion gap, Matsumoto et al. reported that mean joint gap with patella in situ increased during knee flexion from full extension to a peak at 60° flexion, followed by a decrease during the deep knee bend. In contrast, joint gap with patellar eversion showed continuous significant increase, even beyond 60° flexion [12]. Gero et al. measured joint gap and patellar tendon strain from 0° to 135° flexion, with the femoral component in situ, in 20 knees undergoing PS-type TKA: the joint gaps at 90° and 135° with patella in situ were less than with patellar eversion; patellar tendon strain increased with knee flexion, suggesting that the knee extensor system may influence the joint gap [13]. Differences in intraoperative joint gap were also reported not to correlate with the postoperative knee flexion angle [14]. The present study demonstrated that knee extensor system tension is less with the patella in situ, so that the flexion gap is a bit larger than with patellar eversion, without the femoral component in place (Fig. 3).

In a comparative study of flexion gap inclination, Matsumoto et al. reported that patellar reduction lowers tension in the lateral relative to the medial gap of the knee [15]. Yoshino et al. reported that patellar reduction with the femoral component in place did not affect medial or lateral gap tension [16]. Watanabe et al. reported that flexion-gap inclination showed a tendency to be lower with the patella in situ, but measurements varied and failed to show a consistent trend [17]. In the present study, the intraoperative flexion-gap inclination was 4.0 ± 2.9° with patellar eversion and 4.9 ± 3.1° with patellar reduction: i.e., patellar reduction significantly reduced lateral gap tension.

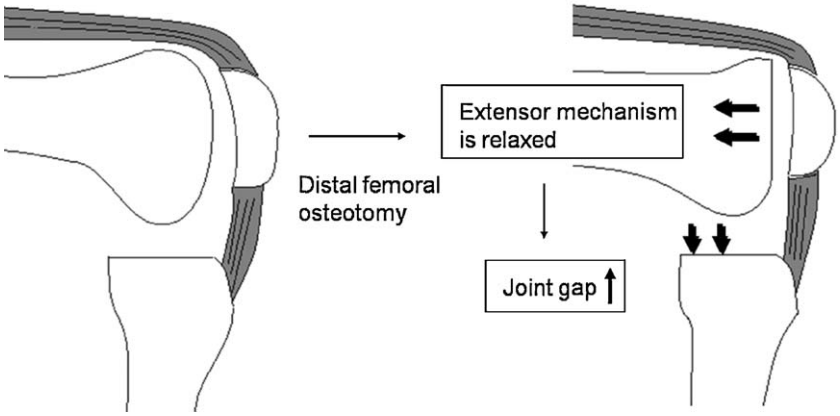


**Figure 3** Knee extensor system tension is lower with the patella in situ, and so the flexion gap is a little larger than with patellar eversion.

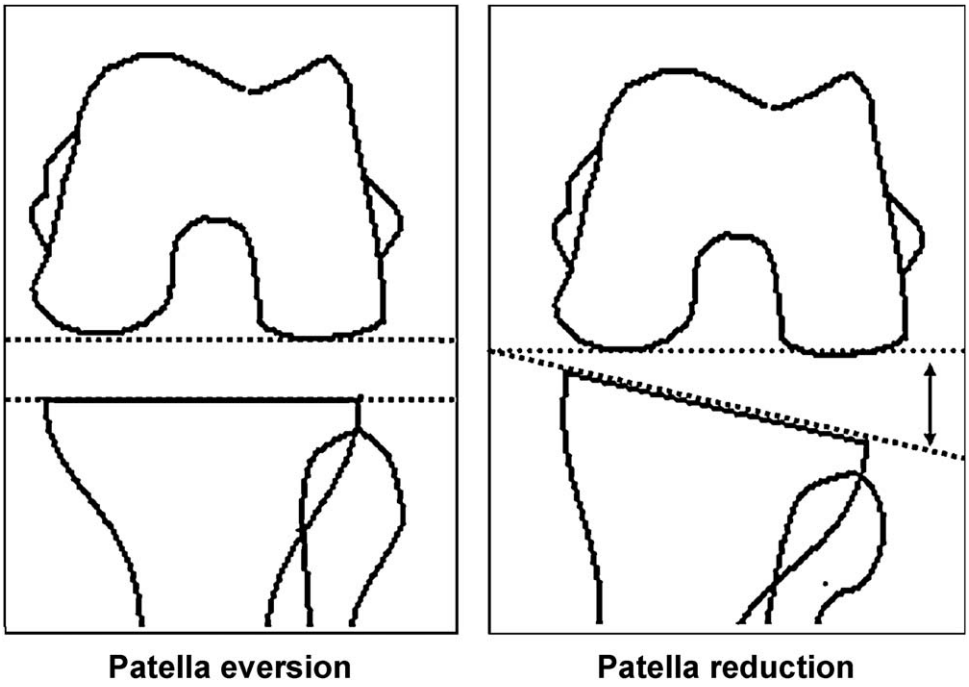


**Figure 4** Flexion-gap inclination with patella in situ tended to be larger than with patellar eversion.

Differences in assessing gap inclination may induce differences in the external rotation of the femoral implant, which is related to deep flexion. Matsui et al. reported that postoperative posterior condylar angle (PCA) was 1.7° when deep flexion was possible and 4.3° when not [18]. Kondo et al. reported that PCA was 0.6° when squatting was steady and 3.4° when not [19], and recommended positioning the femoral component in external rotation. In the present study, the greater flexion-gap inclination with the patella in situ may induce greater femoral component external rotation (Fig. 4), as PCA may tend to be smaller [16].

There are some limitations in the present analysis. First, soft-tissue balance was measured before the femoral component was set, and therefore, may not truly reflect postoperative soft-tissue balance. Soft-tissue balance should be measured before and after the femoral component is set. Secondly, the air tourniquet was inflated to 350 mmHg in all cases during surgery, and the intraoperative flexion gap was measured with the thigh held in place and the leg raised: but the effects of the air tourniquet and lower limb position were not taken into account. Thirdly, no computer-assisted navigation system, which improves the accuracy of the cuts, was used, and this may have influenced flexion gap characteristics [20—23].

## Conclusion

The present study showed that flexion-gap inclination measured with the patella in situ was significantly greater than with patellar eversion, suggesting that the femoral component tended to be in a more externally rotated position. These results ought to be taken into account by surgeons considering switching from conventional TKA (cuts with patellar eversion) to MIS-TKA (cuts with patella in situ).

## Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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